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1 "Exhaust Gas Cooler"

2

3 This invention relates to an exhaust gas cooler for
4 reducing the temperature of exhaust gases from internal
5 combustion engines. In particular the invention
6 relates to an exhaust gas cooler in which a coolant is
7 passed around passages through which the exhaust gas
8 travels.

9

10 Figs. 1a to 1c show a known exhaust gas cooler. This
11 prior art cooler comprises a circular tube 1 which has
12 tapered ends 2 which serve as entry 3 and exit 4
13 orifices for exhaust gases. The orifices are provided
14 with flange plates 10 for connection to exhaust pipes.
15 The ends of the tube are sealed by circular tube plates
16 5 which define a coolant chamber inside the tube. Each
17 tube plate 5 has a number of circular holes 6 arranged
18 through it. The holes 6 in each tube plate 5 are
19 connected by a number of small diameter tubes 7 which
20 are sealed at one end to the first tube plate and at
21 the other end to the second tube plate. Exhaust gases
22 flow into the entry orifice 3, along the inside of the

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1 small diameter tubes 7 and out of the exit orifice 4.
2 The exterior of the tube is provided with entry and
3 exit nozzles 8, 9 which communicate with the coolant
4 chamber for the supply of coolant liquid. A bracket 11
5 is fixed to the tube for mounting the exhaust gas
6 cooler.

7
8 The manufacture of a heat exchanger containing a number
9 of small diameter tubes is difficult and expensive. It
10 is an object of the present invention to provide an
11 exhaust gas cooler of comparable efficiency which can
12 be manufactured more easily and cheaply without
13 compromising cooling flow efficiency.

14
15 According to the present invention there is provided an
16 exhaust gas cooler comprising:
17 a housing having an exhaust gas inlet at a first end
18 and an exhaust gas outlet at a second end,
19 a plurality of spaced apart, coolant passages extending
20 substantially parallel to each other within said
21 housing, wherein each passage comprises two opposing
22 plates and a side wall to couple the two opposing
23 plates together such that the opposing plates form the
24 top and bottom of the coolant passage, and coolant
25 inlet and outlet means communicating with said
26 plurality of coolant passages.

27
28 Preferably, the coolant passages are box-shaped.

29
30 Preferably each plate is provided with surface
31 indentations in the form of ribs. Preferably the ribs
32 extend diagonally across the surface of the plate.

1 Preferably the ribs of the first plate of each passage
2 extend in a first skew direction and the ribs of the
3 second plate of each passage extend in a second skew
4 direction, such that the ribs of the first plate cross
5 the ribs of the second plate. Preferably the ribs are
6 formed as depressions in the plate surface towards the
7 centre of the box. In one embodiment the ribs of the
8 first plate of each passage are in contact with the
9 ribs of the second plate of each passage at the points
10 at which the ribs cross each other. Alternatively in
11 another embodiment the first or second plate is
12 provided with a depression adapted to contact the other
13 of the first and second plates.

14
15 Preferably the side flange of each plate extends around
16 the entire perimeter of the plate. Preferably the
17 first and second plates of each passage are of such a
18 size that the side flange of one of the plates fits
19 within the side flange of the other of the plates.
20 Preferably the side flanges are joined by brazing,
21 welding, adhesive or similar to provide a fluid-tight
22 joint between the plates.

23
24 Preferably the plates are pressed metal plates. The
25 plates may be formed by hydroforming.

26
27 Preferably the ribs are formed as elongate depressions
28 having a round or arcuate shape in cross section.

29
30 Preferably each plate is provided with a first aperture
31 at its first end adapted to communicate with one of
32 said coolant inlet and outlet means. Preferably each

1 plate is provided with a second aperture at its second
2 end adapted to communicate with the other of said
3 coolant inlet and outlet means. Preferably each
4 aperture is surrounded by a sleeve portion adapted to
5 engage with a sleeve portion on the adjacent plate of
6 an adjacent passage to form a coolant conduit
7 connecting the adjacent passages. Preferably the
8 sleeve portion is provided on an opposite face of the
9 plate to the side flanges.

10

11 Preferably the sleeve portion of one of the plates of
12 each passage is adapted to fit within the sleeve
13 portion of the other plate to provide a fluid-tight
14 joint. The joint may be sealed by welding, brazing,
15 adhesive or other sealant. In one embodiment the
16 sleeve portions are shaped so as to hold adjacent
17 passages in spaced apart relationship at a
18 predetermined spacing, for example by providing a
19 stepped formation on one sleeve portion against which
20 the adjacent corresponding sleeve portion abuts. In
21 another embodiment the at least one of first and second
22 plates is provided with one or more outwardly extending
23 depressions adapted to contact the second or first
24 plate of the adjacent passage so as to hold adjacent
25 passages in spaced apart relationship at a
26 predetermined spacing.

27

28 Preferably the plurality of spaced apart, box-shaped
29 coolant passages are in a stacked arrangement, the
30 sleeve portions of the plates being aligned to form a
31 continuous coolant conduit at each end of the housing.
32 Preferably one end of each conduit communicates with

1 one of the coolant inlet and outlet means, while the
2 other end of each conduit is closed off.

3

4 Embodiments of the invention will now be described, by
5 way of example only, with reference to the accompanying
6 figures, where:

7

8 Figs. 1a, 1b, and 1c are a side elevation, a
9 partial sectional view on line A-A, and an end
10 elevation of a prior art exhaust gas cooler;

11 Fig. 2 is a side sectional view through a first
12 embodiment of an exhaust gas cooler according
13 to the invention;

14 Fig. 3a is a plan view of an upper coolant
15 passage plate of the exhaust gas cooler of Fig.
16 2;

17 Fig. 3b is a sectional view on the line A-A of
18 the plate shown in Fig. 3a;

19 Fig. 3c is a sectional view on the line B-B of
20 the plate shown in Fig. 3a;

21 Fig. 3d is a sectional view through a lower
22 coolant passage plate of the exhaust gas cooler
23 of Fig. 2, corresponding to the line A-A in
24 Fig. 3a;

25 Fig. 3e is a sectional view through a lower
26 coolant passage plate of the exhaust gas cooler
27 of Fig. 2, corresponding to the line B-B in
28 Fig. 3a;

29 Fig. 4a is a plan view of a coolant passage of
30 the exhaust gas cooler of Fig. 2;

31 Fig. 4b is a sectional view on the line A-A of
32 the coolant passage of Fig. 4a;

1 Fig. 4c is a sectional view on the line B-B of
2 the coolant passage of Fig. 4a;
3 Fig. 5 is a sectional view on the line B-B of
4 the exhaust gas cooler of Fig. 2;
5 Fig. 6 is a side view of a second embodiment of
6 an exhaust gas cooler according to the
7 invention, with the casing removed for clarity;
8 Fig. 7 is a side view of the exhaust gas cooler
9 of Fig. 6 with the casing in place;
10 Fig. 8 is a plan view of a pair of coolant
11 passage plates forming a coolant passage of the
12 exhaust gas cooler of Fig. 6;
13 Fig. 9a is a sectional view on the line A-A of
14 the coolant passage plates of Fig. 8;
15 Fig. 9b is a sectional view on the line B-B of
16 the coolant passage plates of Fig. 8;
17 Fig. 9c is a sectional view on the line C-C of
18 the coolant passage plates of Fig. 8;
19 Fig. 9d is a sectional view on the line D-D of
20 the coolant passage plates of Fig. 8;
21 Fig. 10a is a plan view of a third embodiment
22 of an exhaust gas cooler according to the
23 invention;
24 Fig. 10b is an end view of the exhaust gas
25 cooler of Fig. 10a;
26 Fig. 10c is a sectional view on the line A-A of
27 the exhaust gas cooler of Fig. 10a;
28 Fig. 11 is a perspective view of the exhaust
29 gas cooler of Fig. 10a showing coolant
30 passages;
31 Fig. 12 is a second perspective view of the
32 exhaust gas cooler of Fig. 10a;

1 Fig. 13a is an enlarged side view of an end
2 portion of a passage of the exhaust gas cooler
3 of Fig. 10a;
4 Fig. 13b is a side view of a passage of the
5 exhaust gas cooler of Fig. 10a;
6 Fig. 13c is an enlarged side view of a second
7 end portion of a passage of the exhaust gas
8 cooler of Fig. 10a;
9 Fig. 13d is a plan view of the passage shown in
10 Fig. 13b;
11 Fig. 13e is an end view of section A-A of the
12 passage shown in Fig. 13d;
13 Fig. 14a is a side view of a housing of the
14 exhaust gas cooler shown in Fig. 10a with the
15 top outer plate removed for clarity;
16 Fig. 14b is a plan view of the housing shown in
17 Fig. 14a;
18 Fig. 15a is a plan view of the housing of the
19 exhaust gas cooler of Fig. 10a with the top and
20 bottom outer plate removed for clarity;
21 Fig. 15b is an end view of section A-A of the
22 housing shown in Fig. 15a;
23 Fig. 15c is a side view of the housing shown in
24 Fig. 15a;
25 Fig. 15d is an end view of section B-B of the
26 housing shown in Fig. 15a;
27 Fig. 16a is an enlarged side view of an end
28 portion of a top inner plate of the exhaust gas
29 cooler of Fig. 10a;
30 Fig. 16b is a side view of the top inner plate
31 of the housing of the exhaust gas cooler of
32 Fig. 10a;

1 Fig. 16c is an enlarged side view of a second
2 end portion of a top inner plate of the housing
3 of the exhaust gas cooler of Fig. 10a;
4 Fig. 16d is a plan view of the top inner plate
5 of Fig. 16b;
6 Fig. 16e is an end view on line A-A of the top
7 inner plate of Fig. 16d;
8 Fig. 17a is a side view of a top outer plate of
9 the exhaust gas cooler of Fig. 10a;
10 Fig. 17b is a plan view of the top outer plate
11 of Fig. 17a;
12 Fig. 17c is an enlarged side view of
13 section A-A of an end portion of the top outer
14 plate of Fig. 17b;
15 Fig. 18a is a side view of a bottom outer plate
16 of the exhaust gas cooler of Fig. 10a;
17 Fig. 18b is a plan view of the bottom outer
18 plate of Fig. 18a; and,
19 Fig. 18c is an enlarged side view of
20 section A-A of the bottom outer plate of Fig.
21 18b.

22
23 The exhaust gas cooler shown in Fig. 2 consists of an
24 external tubular housing 20. At each end of the
25 housing 20 are fixed tapered cap portions 25a, 25b
26 which are adapted to fit over the end of the tubular
27 housing and be fastened by suitable means such as
28 welding. At the narrow end of the tapered cap portion
29 25a is a flange plate 26 provided with two holes 27 for
30 attachment to a corresponding flange plate (not shown)
31 in order to secure the cooler to an exhaust pipe or
32 line (not shown). The flange plates 26 each contain a

1 larger hole which serves as an entry 28 or exit 29
2 orifice for gas.

3

4 A number of box-like coolant passages or tubes 66
5 extend along the tubular housing in a parallel stacked
6 arrangement. Each passage comprises two plates 49, 50
7 are aligned with the longitudinal axis of the tubular
8 housing 20. The plates are provided as pairs 71 with
9 an upper 49 and lower 50 plate forming a tube 66. The
10 plate pairs 71 are parallel with respect to each other.

11

12 Figs. 3a to 3e show the plates 49, 50 in more detail.
13 The plates are generally rectangular in plan, with
14 rounded ends 51, 52 and straight sides 53, 54. The
15 upper plate 49 is provided with a downwardly extending
16 flange 68 around its perimeter, while the lower plate
17 50 is provided with an upwardly extending flange 69
18 around its perimeter. The lower plate 50 is smaller
19 than the upper plate 49, so that the lower flange 69
20 fits securely inside the upper flange 68. The flanges
21 68, 69 are sealed by any suitable means, for example by
22 brazing, welding or adhesive, so that the two plates
23 49, 50 form a fluid-tight passage or tube 66.

24

25 Circular apertures 55, 56 are provided in the plates
26 49, 50 to allow water or any other coolant liquid to
27 flow into one end of the tube 66, along the tube, and
28 out the other end. Circular tapered sleeve portions 57
29 extend upwardly at each end from each upper plate 49,
30 while circular tapered sleeve portions 58 extend
31 downwardly at each end from each lower plate 50. Lip
32 portions 59, 60 are present on the edge of each tapered

1 portion 57, 58 and extend parallel to the main plane of
2 the plate 49, 50. An upwardly extending flange 61 is
3 provided on the lip portion 59 of the upper plate 49
4 which is designed to correspond with the lip portion 60
5 of a lower adjacent plate 50. In this way a lower
6 plate 50 can be stacked on top of an upper plate 49,
7 such that the flange 61 engages inside the lip 60,
8 which will abut the lip 59 and hold the upper and lower
9 plates apart in a predetermined spacing, thereby
10 providing a passage between the coolant tubes 66 for
11 the flow of exhaust gas.

12
13 Alternatively the flange portion 61 may be located on
14 the lip portion 60 of the lower plate 50 adapted to
15 correspond with the lip portion 59 on an upper adjacent
16 plate 49.

17
18 On the planar surface 64, 65 of the plates 49, 50 are
19 diagonally extending grooves or ribs 62, 63.

20
21 Figs. 4a to 4c show a pair of plates 49, 50 joined
22 together to form a tube 66. To join, a pair of plates
23 49, 50 are pressed together so the circumferential
24 flanges 68, 69 fit inside each other as shown in Figs.
25 4b and 4c. The diagonal grooves or ribs 62, 63 extend
26 in opposite diagonal directions to form a criss-cross
27 configuration as shown in Fig. 4a. At the crossover
28 points 67 the ribs 62 of the upper plate 49 are in
29 contact with the ribs 63 of the lower plate 50, so that
30 the plates 49, 50 cannot be pressed together further.
31 Thus the grooves serve as a jig which ensures that the
32 plates are automatically at the correct spacing when

1 they are assembled together. The ribs or grooves 62,
2 63 also serve to increase the turbulence inside and
3 outside the tube 66 which benefits the performance of
4 the exhaust gas cooler.

5
6 During assembly the tubes 66 can be inserted into the
7 body 20 before the tube cap 25a is secured. Adjacent
8 tubes 66 connect with each other at the tapered sleeve
9 portions 57, 58 and engage by means of the lip portions
10 59, 60 and the lip flange 61 as shown in Fig. 5, and as
11 described above. The connection between adjacent
12 sleeve portions can be sealed by any appropriate means,
13 including welding, brazing, solder, adhesive etc. The
14 top sleeve portion 57' engages with the coolant inlet
15 33, while the bottom sleeve portion 58' is closed off
16 with a blanking plate. Equivalent connections are made
17 at the end of the housing with the coolant outlet 34.

18
19 When the assembly is complete exhaust gases flow into
20 the entry orifice 28, and into the body 20 of the
21 exhaust gas cooler 70. The gases flow past the tubes
22 66 and then through the outlet 29.

23
24 A further embodiment of an exhaust gas cooler according
25 to the invention is shown in Figs. 6 to 9. The same
26 reference signs are used to indicate components which
27 are common to the embodiment illustrated in Figs. 2 to
28 5. The cooler has an external tubular casing 120. The
29 casing is formed in two halves 120a, 120b which are
30 joined at an overlap 121. The casing is substantially
31 rectangular in cross section. At each end of the
32 casing 120 there is an end wall 122 which has a tubular

1 passage 123 opening to a flange plate 26 provided with
2 two holes 27 for attachment to a corresponding flange
3 plate (not shown) in order to secure the cooler to an
4 exhaust pipe or line (not shown). The flange plates 26
5 each contain a larger hole which serves as an entry 28
6 or exit 29 orifice for the exhaust gas.

7
8 As in the first embodiment, a number of box-like
9 coolant passages or tubes 166 extend along the tubular
10 housing in a parallel stacked arrangement. Each
11 passage comprises two plates 149, 150 arranged parallel
12 to each other and to the longitudinal axis of the
13 tubular housing 120. The plates are provided as pairs
14 171 with an upper 149 and lower 150 plate forming a
15 tube 166. The pairs 171 of plates are arranged
16 parallel to each other.

17
18 Figs. 8 and 9a to 9d show the plates 149, 150 in more
19 detail. The plates are generally rectangular in plan,
20 with rounded ends 51, 52 and straight sides 53, 54.
21 The upper plate 149 is provided with a downwardly
22 extending flange 168 around its perimeter, while the
23 lower plate 150 is provided with an upwardly extending
24 flange 169 around its perimeter. The lower plate 150
25 is larger than the upper plate 149, so that the upper
26 flange 168 fits securely inside the lower flange 169.
27 The flanges 168, 169 are sealed by any suitable means,
28 for example by brazing, welding or adhesive, so that
29 the two plates 149, 150 form a fluid-tight passage or
30 tube 166.

31

1 Circular apertures 55, 56 are provided in the plates
2 149, 150 to allow water or any other coolant liquid to
3 flow into one end of the tube 166, along the tube, and
4 out the other end. Circular sleeve portions 157a, 157b
5 extend upwardly at each end from each upper plate 149,
6 while circular sleeve portions 158a, 158b, adapted to
7 fit within or around sleeves 157a, 157b, extend
8 downwardly at each end from each lower plate 150.

9
10 The lower plate 150 is provided with an upwardly
11 extending circular depression 159, which engages with
12 the upper plate 149 when the upper plate 149 is placed
13 inside the lower plate 150, to hold the upper and lower
14 plates apart in a predetermined spacing, typically 3 to
15 6 mm, thereby providing a coolant tube 166. The
16 depression 159 may be connected by a spot weld 160.
17 Additional spot welding may be provided, together with
18 additional depressions 159, if required. The spot
19 welding may be omitted if a fluid tight tube is
20 achieved by secure interconnection of the upper and
21 lower plates 149, 150 at their perimeters and/or
22 openings 55, 56.

23
24 On the planar surface of the plates 149, 150 are
25 diagonally extending grooves or ribs 162, 163, formed
26 as depressions outwards from the other of the pair of
27 plates 149, 150. The ribs 162, 163 extend in opposite
28 diagonal directions to form a criss-cross
29 configuration, as described above with reference to
30 Figs. 2 to 5. However the ribs 162, 163 do not have to
31 serve as a jig to control the spacing of the plates
32 149, 150, since this function is served by the

1 depression 159. The ribs 162, 163 serve to increase
2 the turbulence inside and outside the tube 166. If
3 desired the ribs 162, 163 may be reversed in direction
4 so that they are formed as inward depressions. The rib
5 pattern may be varied.

6
7 Spacing indentations 170 which extend upwardly in the
8 upper plate 149 and downwardly in the lower plate 150
9 are provided at six locations. The number of locations
10 may be varied. These serve to space apart the pairs
11 171 of plates when they are stacked, thereby permitting
12 the passage of exhaust gases between the pairs 171 of
13 plates. The spacing 190 between adjacent pairs is
14 typically between 3 and 6 mm.

15
16 In the example shown in Figs. 6 and 7 the upper plate
17 of the upper passage 166 is formed from a plane plate
18 201 which forms part of the casing 120. Similarly the
19 lower plate of the lower passage 166 is formed from a
20 plane plate 202 which forms part of the casing 120.
21 These plane plates 201, 202 extend beyond the other
22 plates 149, 150. The plane plates 201, 202 may be
23 provided with ribs.

24
25 The coolant inlet 33 and coolant outlet 34 join at
26 opposite ends of the body 20 or casing 120. In the
27 embodiment illustrated both the inlet and outlet pipes
28 33, 34 incorporate a 90° bend, so that the hose
29 connections to the ends 35 of the pipes 33, 34 may be
30 made parallel to the longitudinal axis of the body 20
31 or casing 120. It is to be understood that either of
32 the inlet or outlet pipes 33, 34 may be straight so

1 that the hose connections to the ends 35 may be made
2 perpendicular to the longitudinal axis 50 of the tube,
3 or that either of the inlet or outlet pipes 33, 34 may
4 incorporate a bend of an intermediate angle less than
5 90°. Either of the inlet or outlet pipes 33, 34 may be
6 reversed so that the open end 35 faces towards the
7 centre of the exhaust gas cooler, instead of facing
8 away from the centre of the exhaust gas cooler as shown
9 in Fig. 2.

10

11 The efficiency of the tubes 66 alleviates the need for
12 additional cooling fins. The grooves 62, 63 provide a
13 means for self jiggling the pair of plates 49, 50 which
14 make up the tube 66, and so simplify the assembly of
15 the exhaust gas cooler in addition to increasing the
16 exhaust gas and coolant liquid turbulence.

17

18 Although the grooves or ribs 62, 63 are illustrated as
19 arc-shaped in cross-section, it is to be understood
20 that other shapes can be used, for example, U-shape, V-
21 shape, trapezoidal, rectangular, semi-circular etc.

22

23 The plates 49, 50, 149, 150 are easy to manufacture and
24 assemble compared with small diameter tubes used in the
25 prior art, since they can be made as simple sheet
26 pressings.

27

28 Although the plates 49, 50, 149, 150 of the cooler are
29 shown as pressings, the passages or tubes 66, 166 may
30 be manufactured by any suitable method, for example by
31 hydroforming.

1 A third preferred embodiment of a gas cooler is shown
2 in Figs. 10-18. The same reference numerals have been
3 used for the third embodiment as were used for the
4 previous embodiments but, in this case, preceded by a
5 '2'.

6
7 The cooler has a housing 220 with an internal
8 substantially rectangular shaped cross-section bore and
9 an external substantially rectangular shaped cross
10 section; alternatively the housing 220 may be formed
11 with a substantially oval-shape cross-section. Five
12 tubes 266 are arranged within the housing as described
13 for previous embodiments, although it will be
14 appreciated that any number of tubes may be included in
15 the housing.

16
17 The tubes 266 are formed from transforming a
18 cylindrical tube into the oval-like passage by any
19 suitable means, for example, by compression of the
20 cylindrical tube within a suitably sized mould. Thus
21 the manufacturing process may be simplified further in
22 that the plates 249, 250 which form the tube 266 may be
23 formed integrally from a one piece tube instead of two
24 separate plates. Thus, in this preferred third
25 embodiment, the tubes 266 comprise top 249 and bottom
26 250 plates which oppose each other, and a side wall 268
27 to couple the two opposing plates 249, 250 together.

28
29 Figs. 11, 12 show the third embodiment in perspective
30 view comprising the housing 220 with a flange 226 at
31 each end thereof, a coolant inlet 233, coolant outlet
32 234, a top inner plate 280 (not shown in Figs. 11, 12),

1 a top outer plate 280, a bottom outer plate 290 (not
2 shown in Figs. 11, 12) and the five tubes 266. The
3 skilled reader will realise that the coolant inlet 233
4 could alternatively be configured to be a coolant
5 outlet 233, and the coolant outlet 234 could
6 alternatively be configured to be a coolant inlet 234.
7

8 The passages 266 are shown in more detail in Fig. 13a-
9 13e. On the planar surface of the plates 249, 250 are
10 diagonally extending grooves or ribs 262, 263 formed as
11 depressions outwards from the other of the pair of
12 plates 249, 250. The ribs extend in opposite diagonal
13 directions to form a criss-cross configuration, as
14 described above with reference to previous embodiments.
15 The ribs 262, 263 do not have to serve as a jig to
16 control the spacing of the plates 249, 250, since this
17 function is served by a depression 259 or a sleeve 255.
18 The ribs 262, 263 and in particular the criss-cross
19 configuration of the ribs 262, 263 serve to increase
20 the turbulence of the coolant inside the passages 266
21 and the exhaust gas outside the passages 266 thereby
22 helping to increase the efficiency of the exhaust gas
23 cooler. If desired the ribs may be reversed in
24 direction so that they are formed as inward
25 depressions. The rib pattern may be varied.
26

27 The housing 220 is shown in more detail in Figs. 14a,
28 14b and particularly Figs 15a-d. An inwardly extending
29 portion 291 is provided at the bottom of the housing
30 220. The bottom outer plate 290 (shown in Figs. 18a-
31 18e) is attached to the outer face of the bottom of the
32 housing 220, thus forming a further passage 292 for

1 coolant to flow through between the inwardly extending
2 portion 291 of the housing and the bottom outer plate
3 290. Apertures 355 and sleeve portions 359 are
4 provided to connect the further passage 292 with the
5 passages 266 as described for the inter-passage
6 connections of previous embodiments.

7
8 The inwardly extending portion 291 has ribs 362 running
9 along the bottom of the housing 220. A criss-cross
10 pattern is formed between the ribs 362 of the bottom of
11 the housing 220 and the ribs 263 on the lower plate 250
12 of the lowermost passage 266'' causing increased
13 turbulence of the exhaust gas flowing therethrough.

14
15 The top inner plate 295, shown in Figs. 16a-16e, has an
16 inwardly extending portion 296 and connects via
17 aperture 455 to the sleeves 257 of the upper plate 249
18 of the uppermost passage 266' as previously described
19 above with respect to the lower inner plate 290. An
20 upper outer plate 280 is attached at the top of the
21 housing 220 and provides for a further coolant passage
22 297 between top outer 280 and top inner 295 plates.
23 Thus coolant may flow to and from the further coolant
24 passage 297 and the coolant passages 266 via the
25 connection between the aperture 455 and the sleeve 257.

26
27 The upper inner plate 295 has ribs 463 extending
28 further inwards towards the uppermost passage 266'.
29 The ribs 463 run in a diagonal pattern as shown in Fig.
30 16d. Normally the ribs 463 will form a criss-cross
31 pattern with the ribs 262 of the upper plate 249 of the

1 uppermost tube 266' thereby increasing turbulence of
2 the exhaust gas passing therebetween.

3
4 Thus there are a total of seven coolant passages in the
5 third embodiment, five formed from the plates 249, 250
6 and one at the top of the housing 220 formed between
7 the top outer 280 and top inner 295 plates and one at
8 the bottom of the housing 220 formed between the bottom
9 of the housing and the bottom outer plate 290.

10
11 The shape of the body 220 is preferably rectangular
12 which allows a more efficient use of space within an
13 engine.

14
15 The exhaust gas flow is open, with minimal
16 obstructions, so that fouling of the exhaust gas cooler
17 is minimised.

18
19 The exhaust gas cooler of the present invention is
20 manufactured from components which are themselves cheap
21 and easy to manufacture and straightforward to
22 assemble, since no separate jigging of the component
23 parts is necessary.

24
25 In alternative embodiments a corrugated sheet may be
26 provided between the passages 266 in order to increase
27 the turbulence of the exhaust gas flow thereby
28 increasing the efficiency of the exhaust gas cooler. In
29 such embodiments the sheet has an aperture at each end
30 to be placed around the sleeves 257 of the plates 249,
31 250. The corrugated sheet thus provides a fluid flow
32 interruption mechanism.

1
2 These and other modifications and improvements can be
3 incorporated without departing from the scope of the
4 invention.

1 **Claims**

2

3 1. An exhaust gas cooler comprising:
4 a housing having an exhaust gas inlet at a first end
5 and an exhaust gas outlet at a second end,
6 a plurality of spaced apart, coolant passages
7 extending substantially parallel to each other
8 within said housing, wherein each passage comprises
9 two opposing plates and a side wall to couple the
10 two opposing plates together such that the opposing
11 plates form the top and bottom of the coolant
12 passage, and coolant inlet and outlet means
13 communicating with said plurality of coolant
14 passages.

15

16 2. An exhaust gas cooler as claimed in claim 1,
17 wherein each plate is provided with surface
18 indentations, and each coolant passage is one of
19 box- and oval-shaped.

20

21 3. An exhaust gas cooler as claimed in claim 2,
22 wherein the surface indentations are in the form of
23 ribs.

24

25 4. An exhaust gas cooler as claimed in claim 3,
26 wherein the ribs extend diagonally across the
27 surface of each plate.

28

29 5. An exhaust gas cooler as claimed in claims 3 or
30 4, wherein the ribs are formed as depressions in the
31 plate surface towards the centre of the coolant
32 passage.

1

2 6. An exhaust gas cooler as claimed in one of
3 claims 3 to 5, wherein ribs of the first plate of
4 each passage extend in a first skew direction and
5 ribs of the second plate of each passage extend in a
6 second skew direction, such that ribs of the first
7 plate cross ribs of the second plate.

8

9 7. An exhaust gas cooler as claimed in claim 6,
10 wherein ribs of the first plate of each passage are
11 in contact with ribs of the second plate of each
12 passage at the points at which the ribs cross each
13 other.

14

15 8. An exhaust gas cooler as claimed in any
16 preceding claim, wherein the first or second plate
17 of a first passage is provided with a depression
18 adapted to contact a first or second plate of a
19 second passage so as to hold adjacent passages in
20 spaced apart relationship at a predetermined
21 spacing.

22

23 9. An exhaust gas cooler as claimed in any
24 preceding claim, wherein the side wall of each
25 passage extends around the entire perimeter of the
26 passage.

27

28 10. An exhaust gas cooler as claimed in any
29 preceding claim, wherein the side walls are provided
30 on each opposing plate interengaging with one
31 another, and the opposing plates of each passage are
32 of such a size that the side flange portion of one

1 of the plates fits within the side flange portion of
2 the other of the plates.

3

4 11. An exhaust gas cooler as claimed in any
5 preceding claim, wherein the plates are pressed
6 metal plates.

7

8 12. An exhaust gas cooler as claimed in any
9 preceding claim, wherein the plates are formed by
10 hydroforming.

11

12 13. An exhaust gas cooler as claimed in any of
13 claims 2-12, wherein the ribs are formed as elongate
14 depressions having an arcuate shape in cross
15 section.

16

17 14. An exhaust gas cooler as claimed in any
18 preceding claim, wherein each plate is provided with
19 a first aperture at its first end adapted to
20 communicate with one of said coolant inlet and
21 outlet means.

22

23 15. An exhaust gas cooler as claimed in claim 14,
24 wherein each plate is provided with a second
25 aperture at its second end adapted to communicate
26 with the other of said coolant inlet and outlet
27 means.

28

29 16. An exhaust gas cooler as claimed in claim 14 or
30 claim 15, wherein each aperture is surrounded by a
31 sleeve portion adapted to engage with a sleeve
32 portion on an adjacent plate of an adjacent passage

1 to form a coolant conduit connecting the adjacent
2 passages.

3

4 17. An exhaust gas cooler as claimed in claim 16
5 when dependent on claim 10, wherein the sleeve
6 portion is provided on an opposite face of the plate
7 to the side flanges.

8

9 18. An exhaust gas cooler as claimed in claim 16 or
10 claim 17, wherein the sleeve portion of one of the
11 plates of each passage is adapted to fit within the
12 sleeve portion of the other plate of another passage
13 to provide a fluid-tight joint.

14

15 19. An exhaust gas cooler as claimed in any of
16 claims 16 to 18, wherein the sleeve portions are
17 shaped so as to hold adjacent passages in spaced
18 apart relationship at a predetermined spacing.

19

20 20. An exhaust gas cooler, as claimed in claim 19,
21 wherein a stepped formation is provided on one
22 sleeve portion against which an adjacent
23 corresponding sleeve portion of an adjacent plate of
24 an adjacent passage abuts so as to hold the adjacent
25 passages in spaced apart relationship at a
26 predetermined spacing.

27

28 21. An exhaust gas cooler, as claimed in claim 8 or
29 claim 20 or to one of claims 9 to 19 when dependent
30 on claim 8, wherein the plurality of spaced apart,
31 coolant passages are in a stacked arrangement.

32

1 22. An exhaust gas cooler, as claimed in any one of
2 claims 16 to 21 when dependent on claim 16, wherein
3 the sleeve portions of the plates are aligned to
4 form a continuous coolant conduit at each end of the
5 housing.

6
7 23. An exhaust gas cooler as claimed in claim 22,
8 wherein one end of each conduit communicates with
9 one of the coolant inlet and outlet means, while the
10 other end of each conduit is closed off.

11
12 24. An exhaust gas cooler, as claimed in any
13 preceding claim, wherein the housing has a square,
14 oval or rectangular cross section.

15
16 25. An exhaust gas cooler as claimed in any one of
17 claims 3 or 4, wherein the ribs are formed as
18 depressions in the plate surface away from the
19 centre of the coolant passage.

20
21 26. An exhaust gas cooler as claimed in any
22 preceding claim, wherein a fluid flow interruption
23 mechanism is provided between the coolant passages.

24
25 27. A method of manufacturing the coolant passages
26 as claimed in any preceding claim, wherein a tube is
27 compressed to form the coolant passages.

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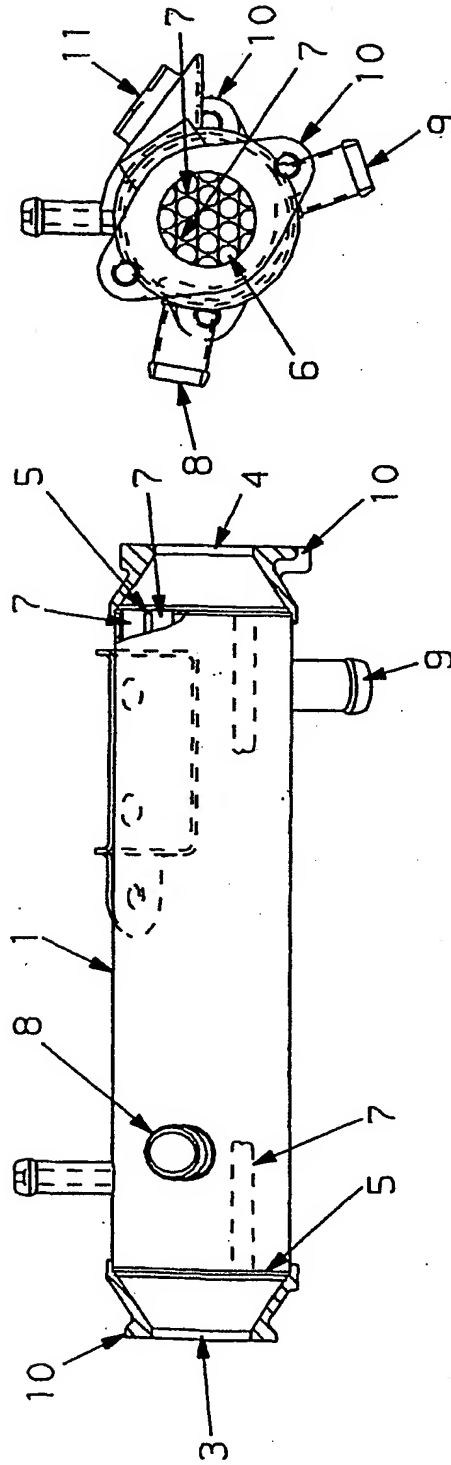
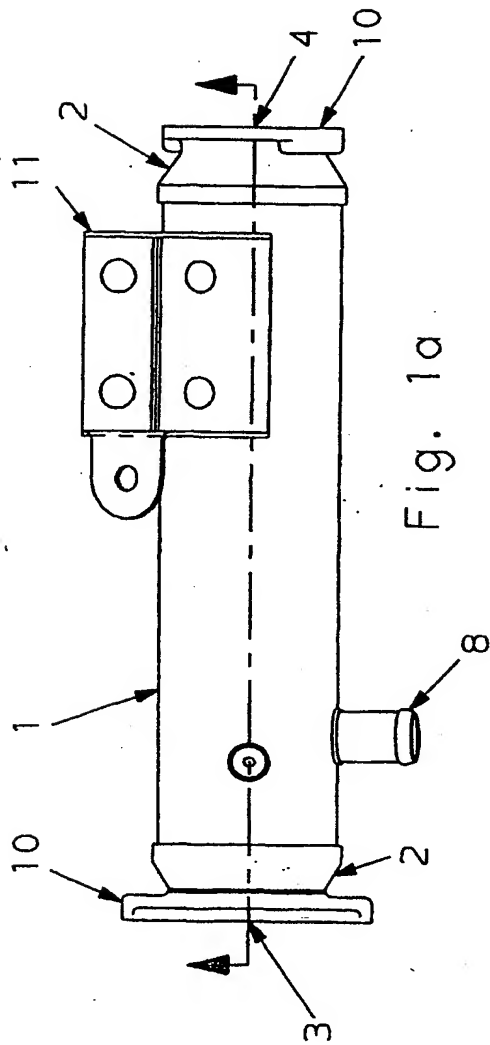
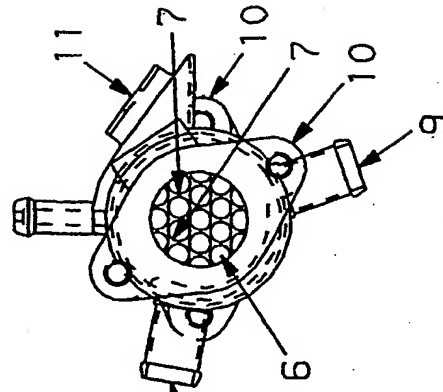
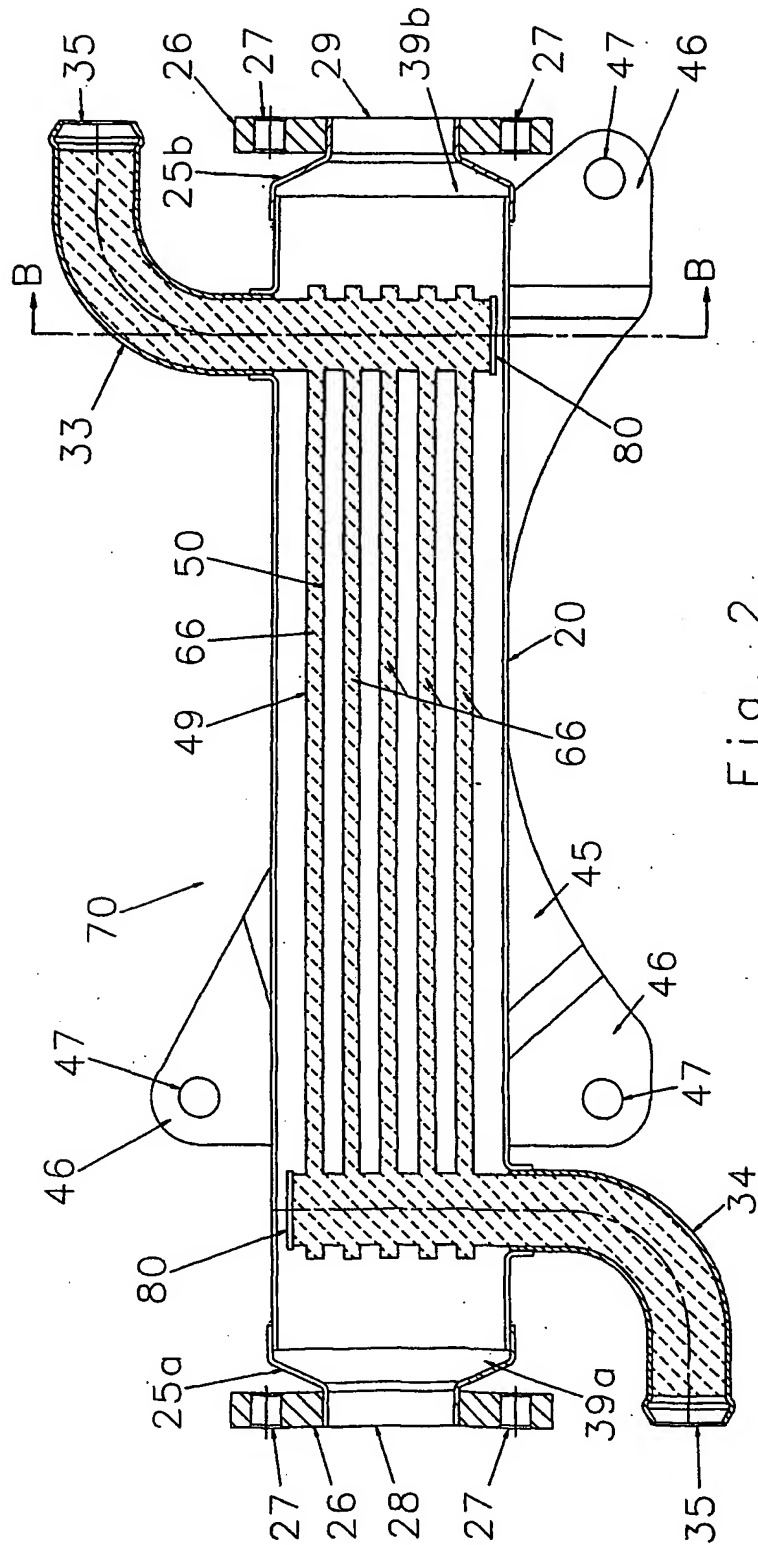


Fig. 1c

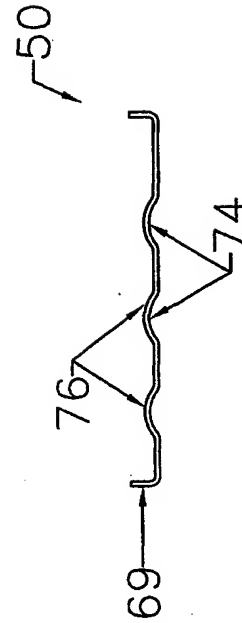
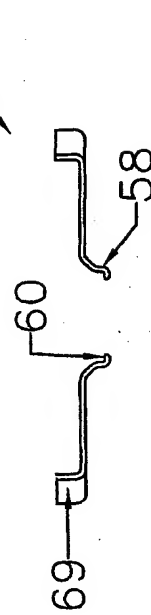
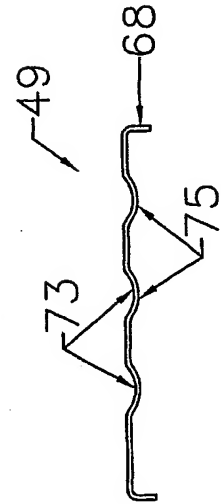
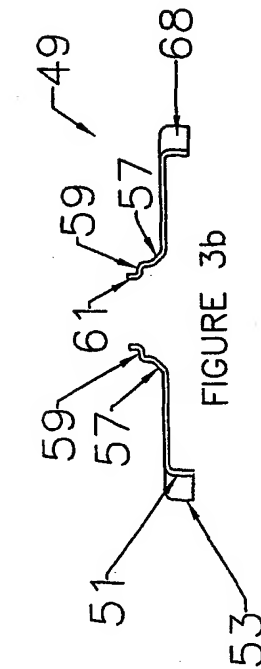
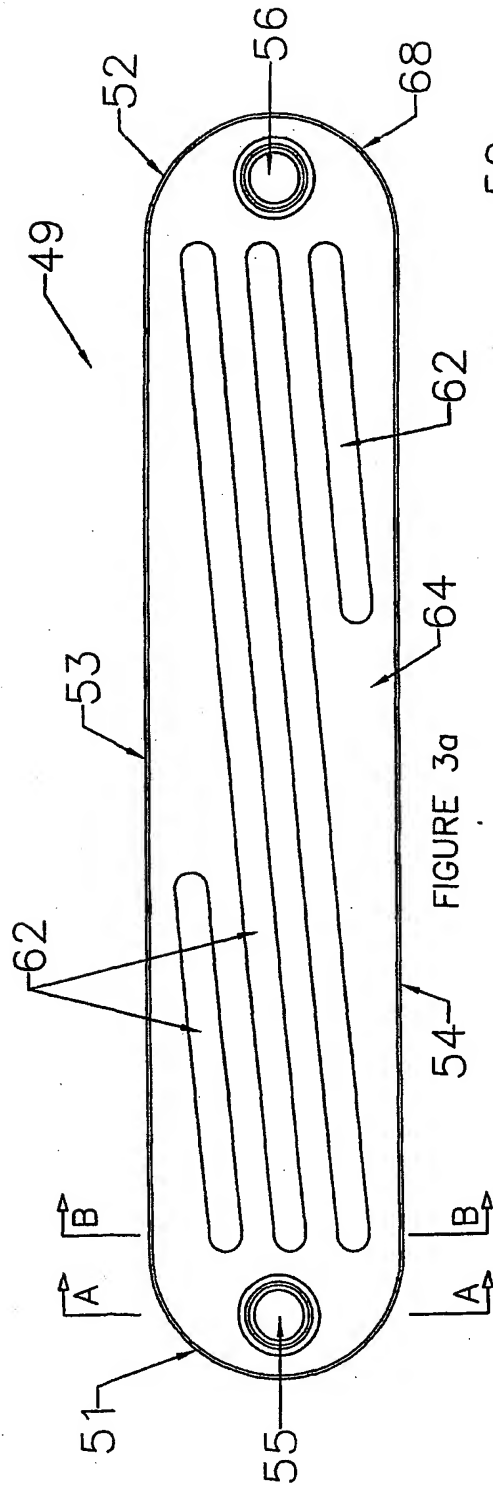


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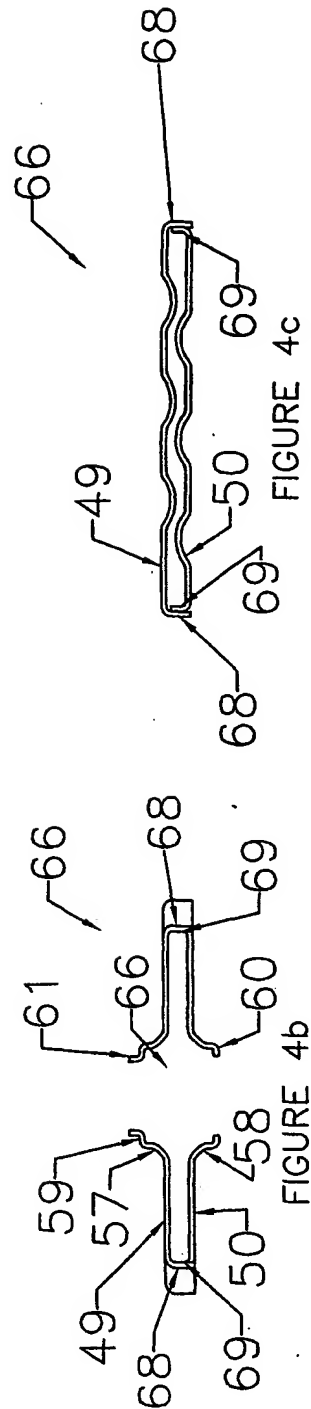
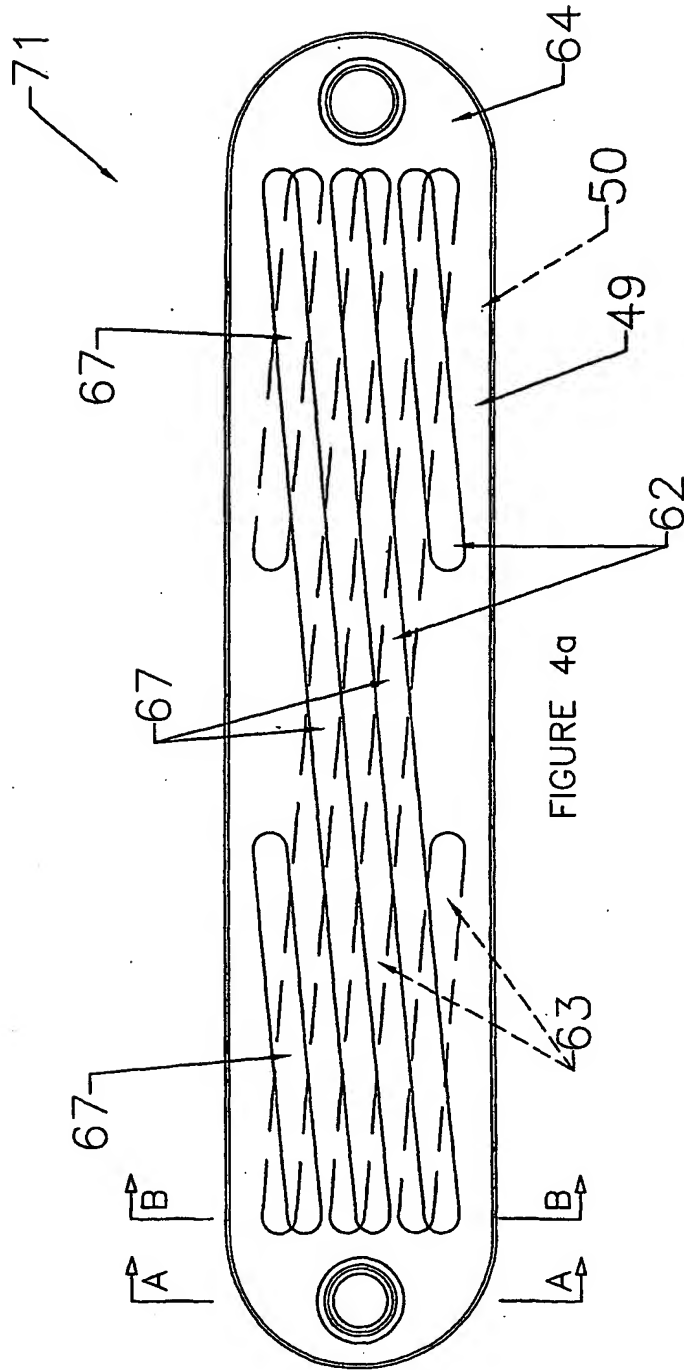


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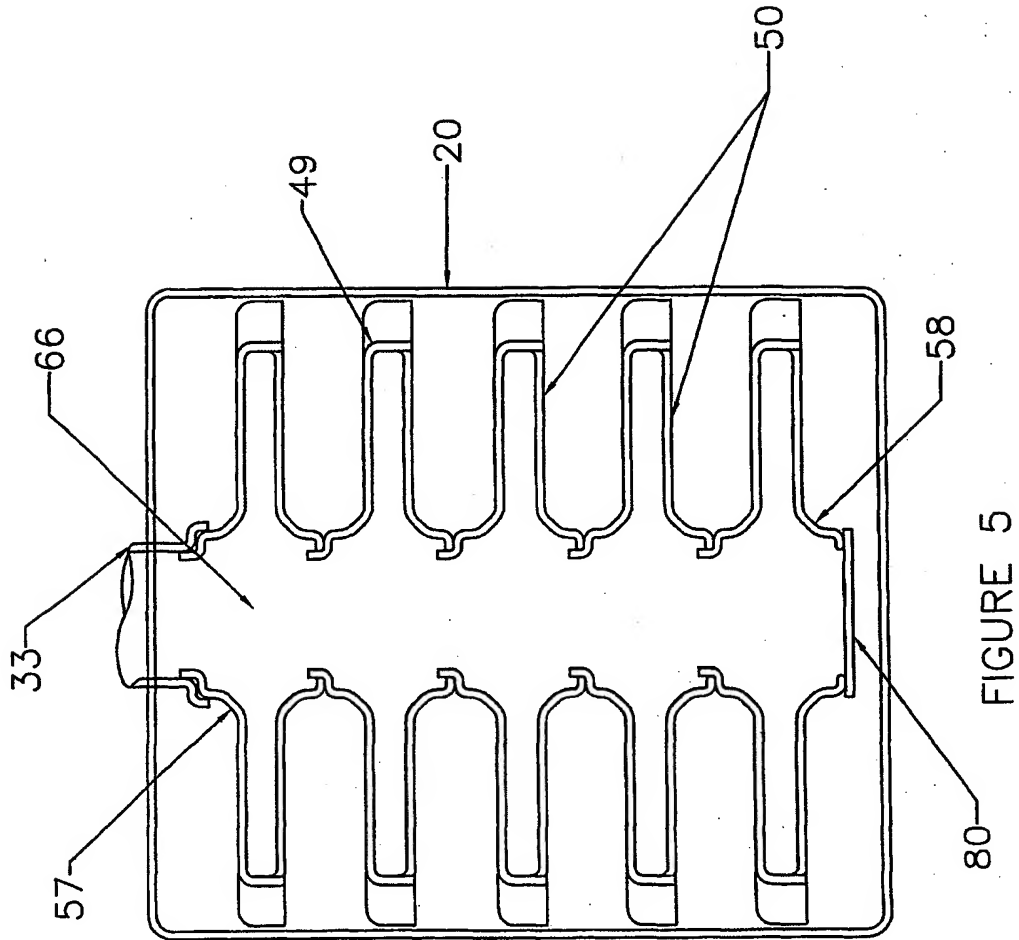
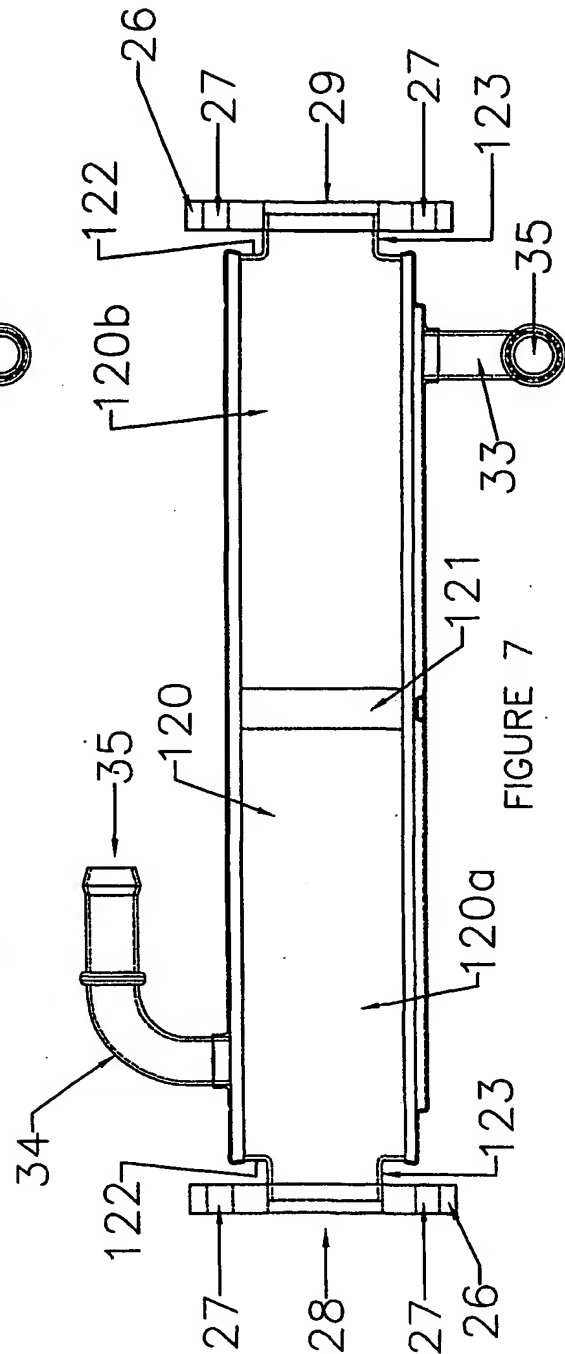
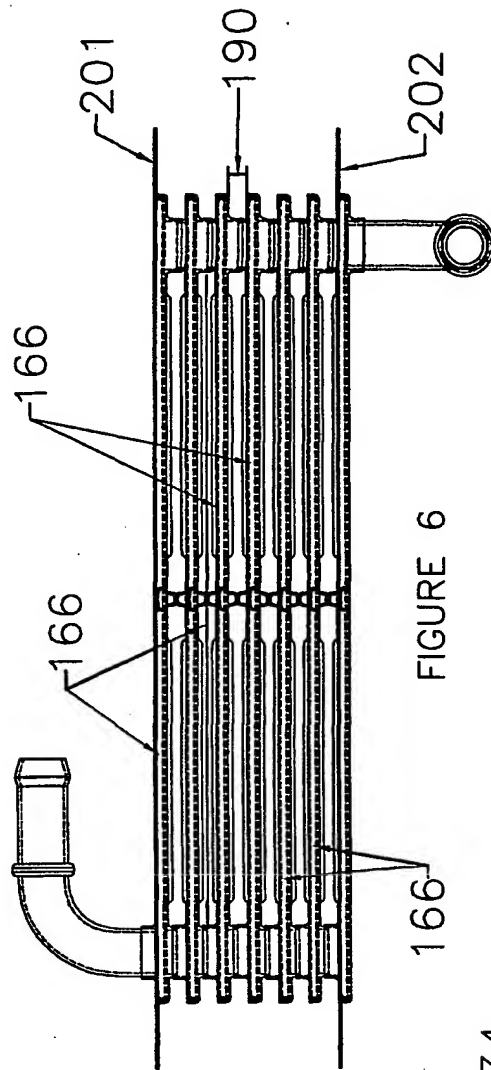
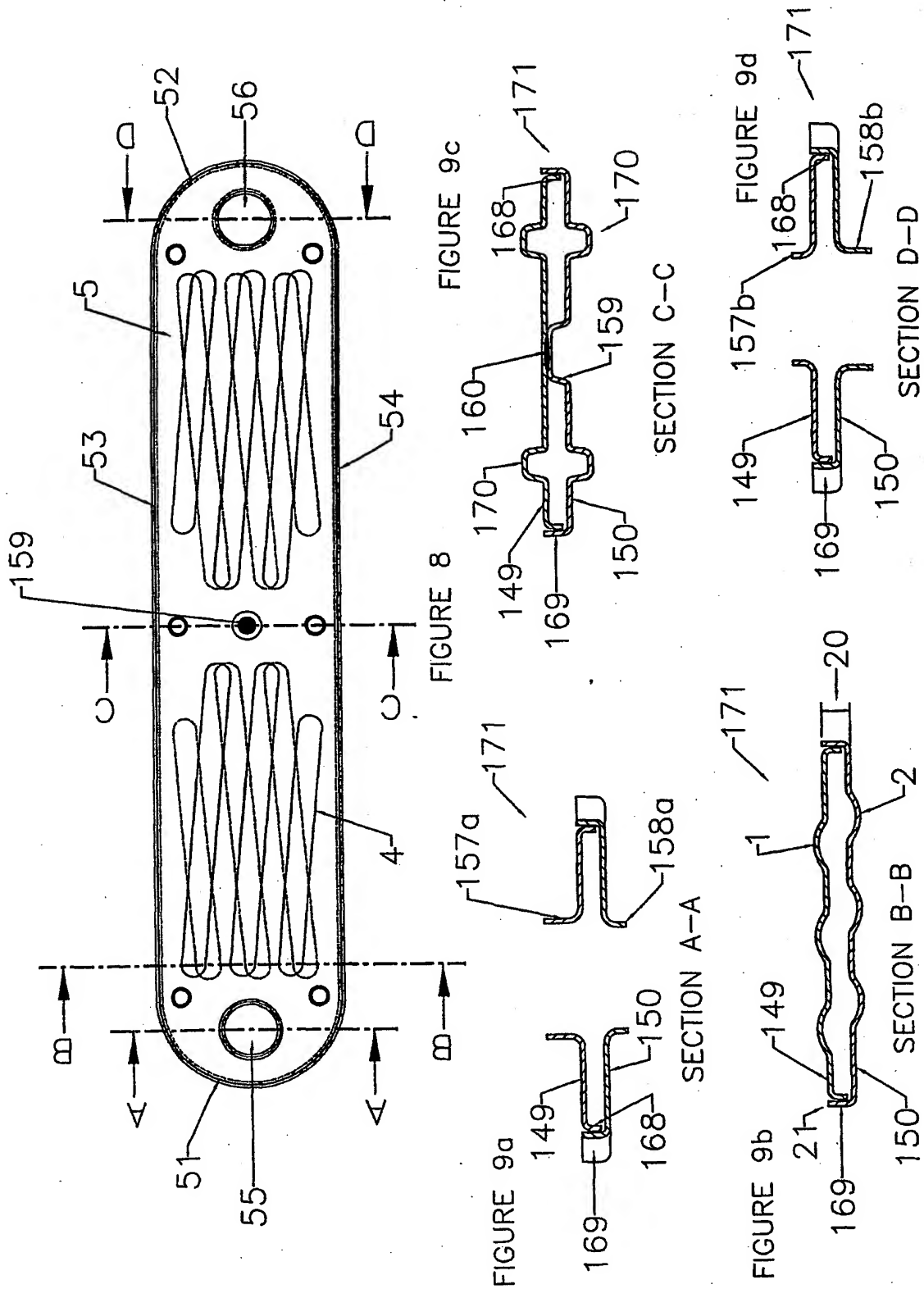


FIGURE 5

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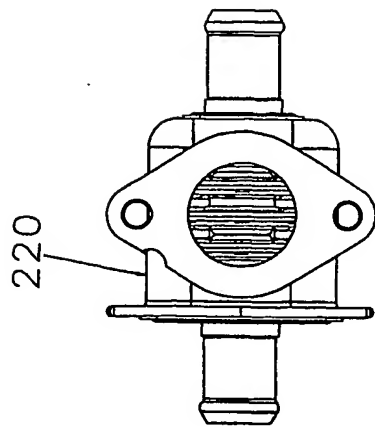


Fig. 10b

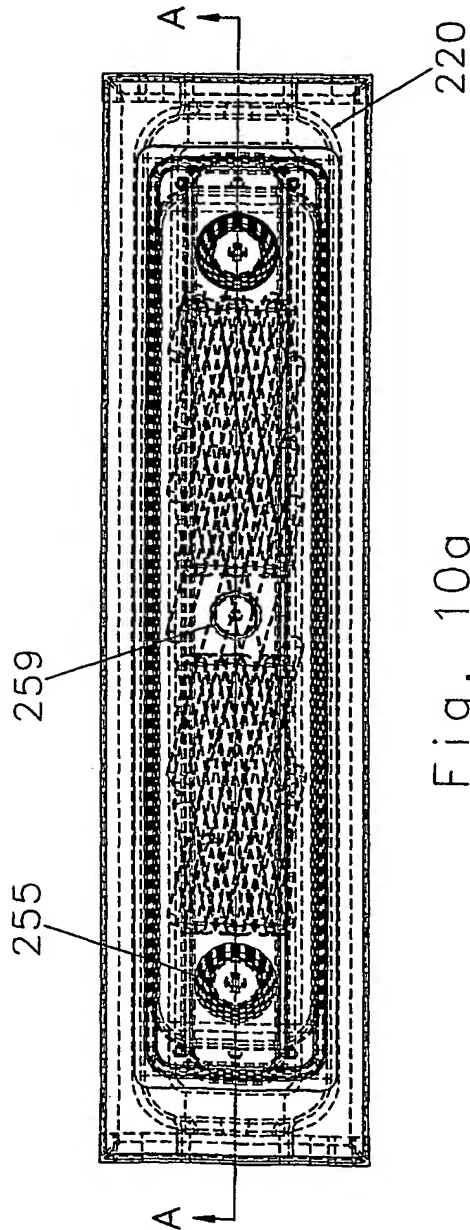


Fig. 10a

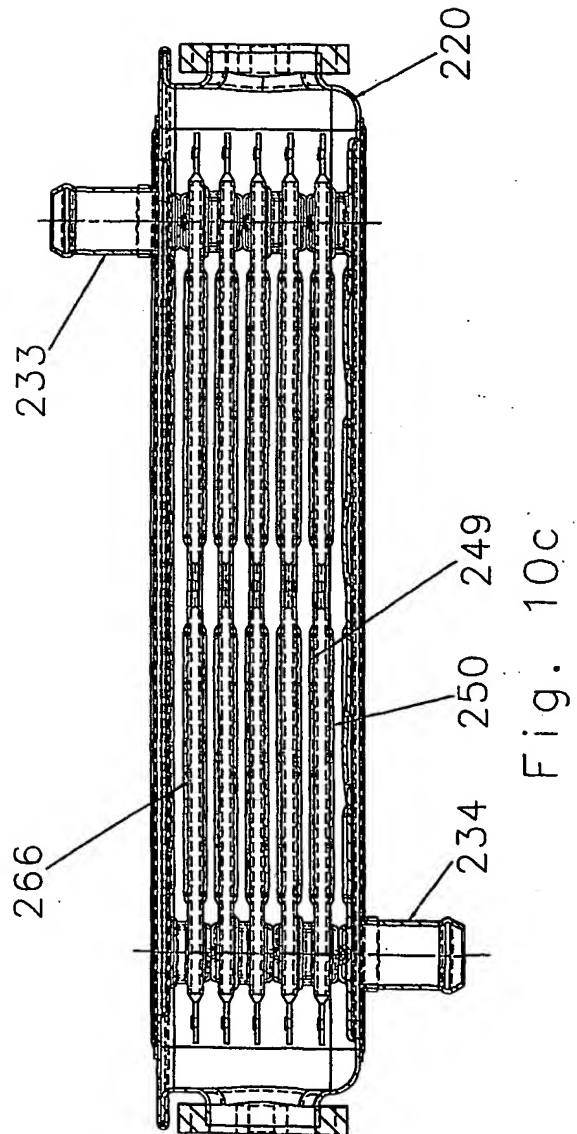


Fig. 10c

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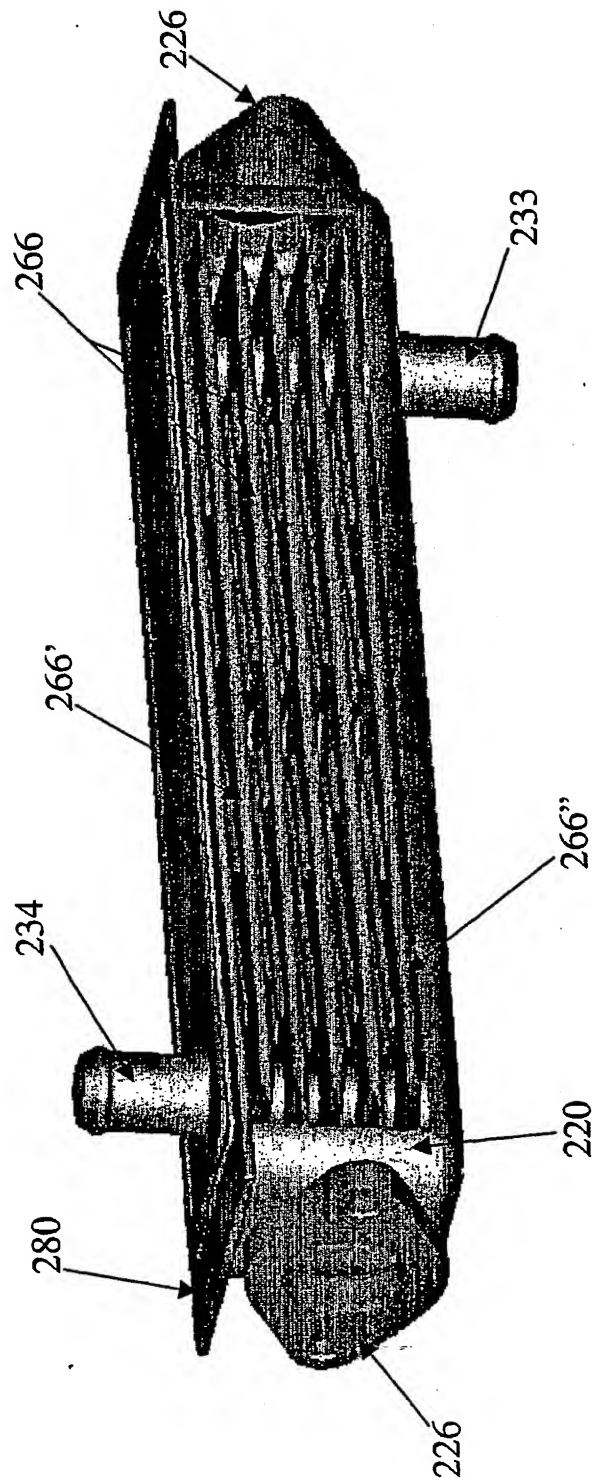


FIG 11

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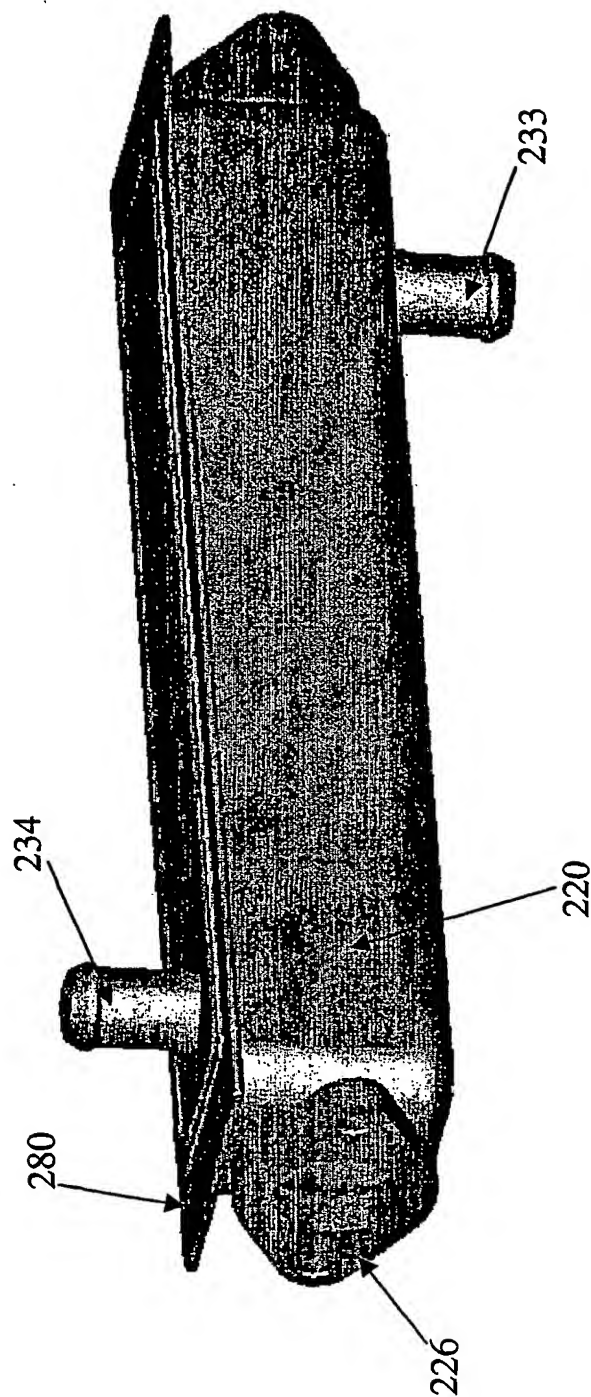
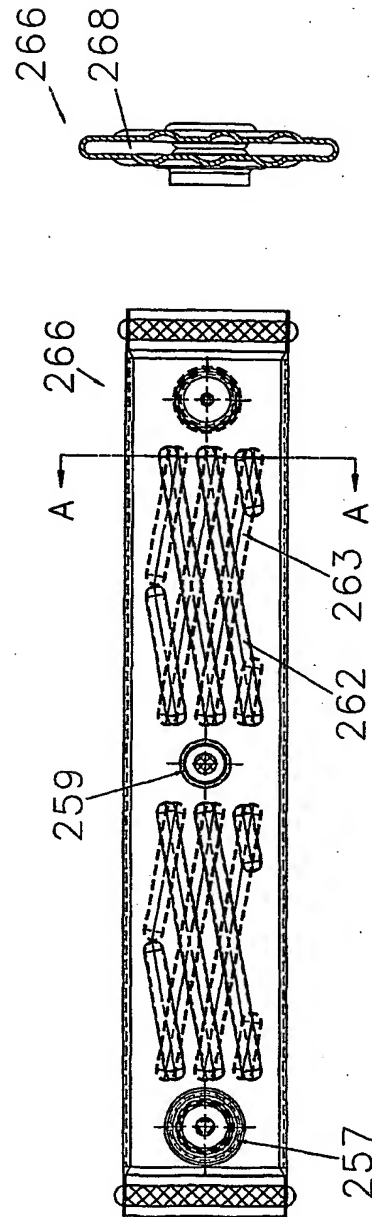
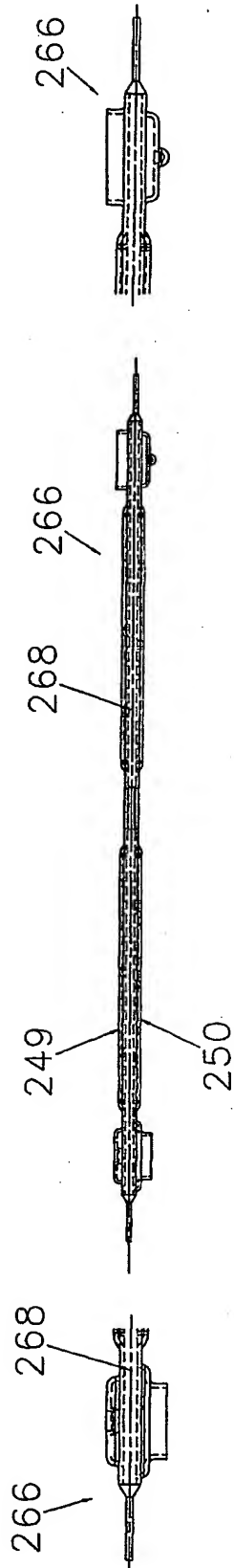


FIG 12

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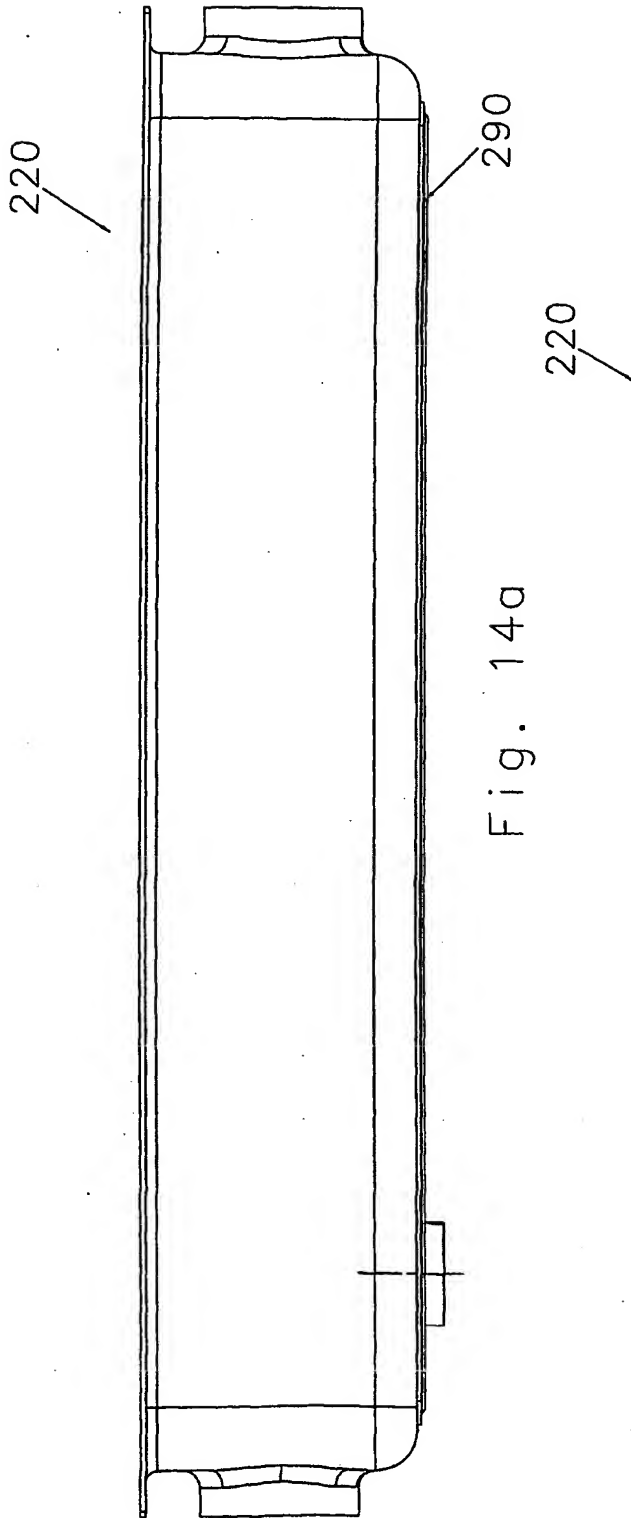


Fig. 14a

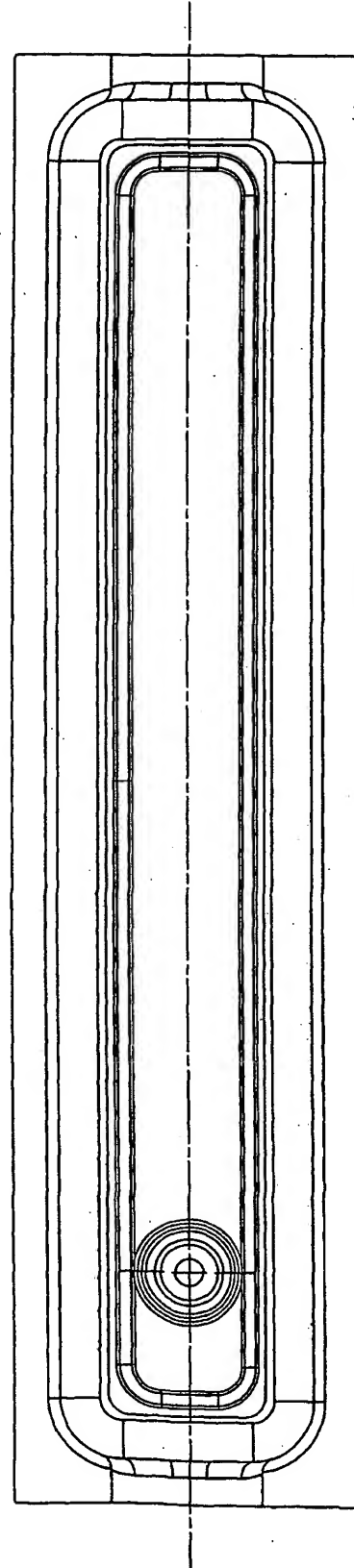


Fig. 14b

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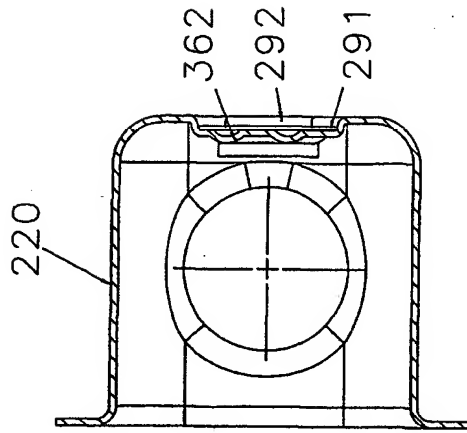


Fig. 15b

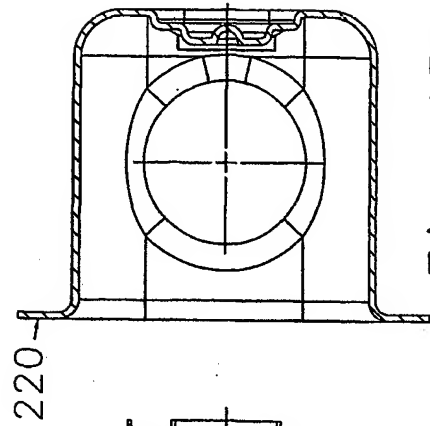


Fig. 15d

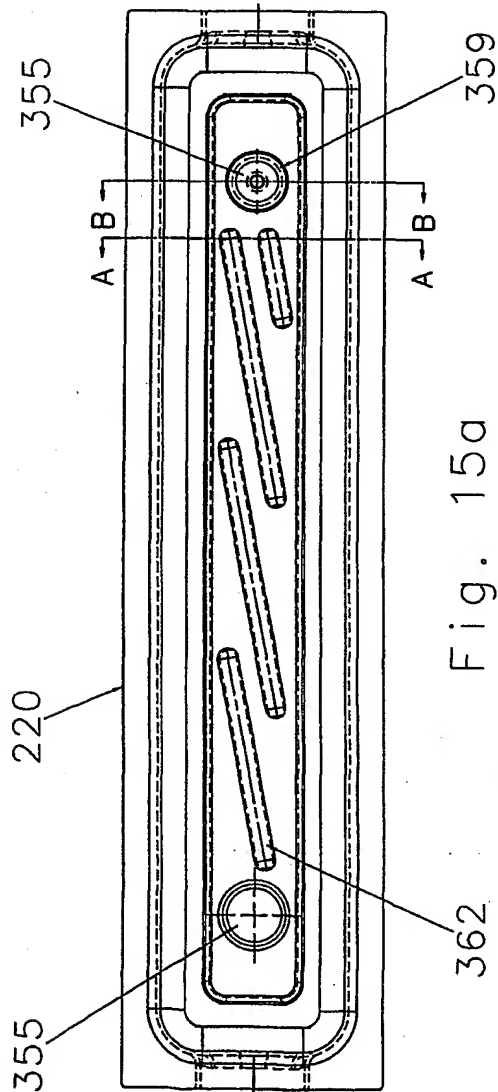


Fig. 15a

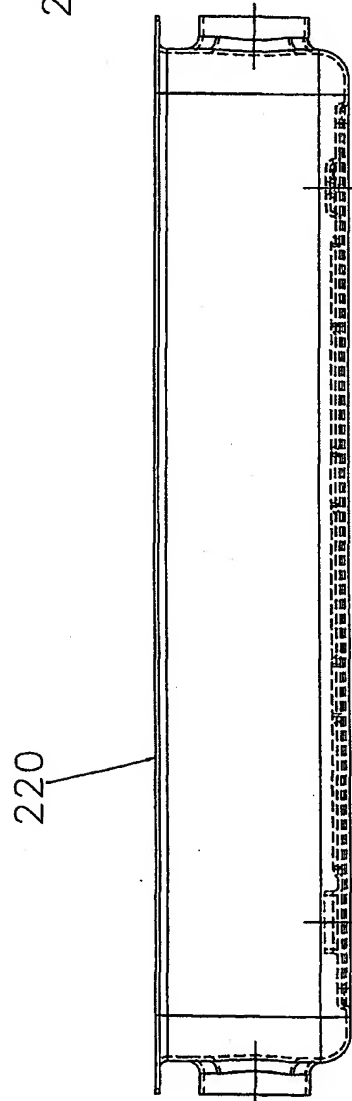


Fig. 15c

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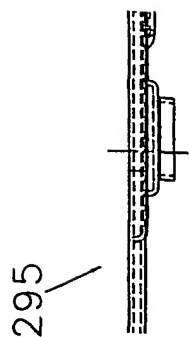


Fig. 16a



Fig. 16b

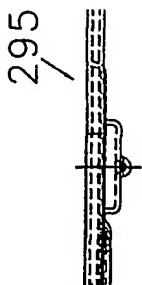


Fig. 16c

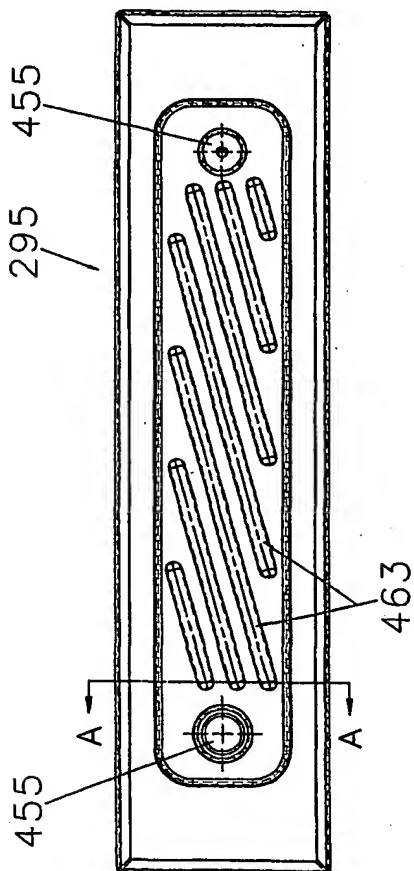


Fig. 16d

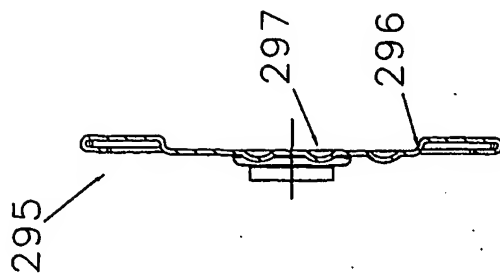


Fig. 16e

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Fig. 17a

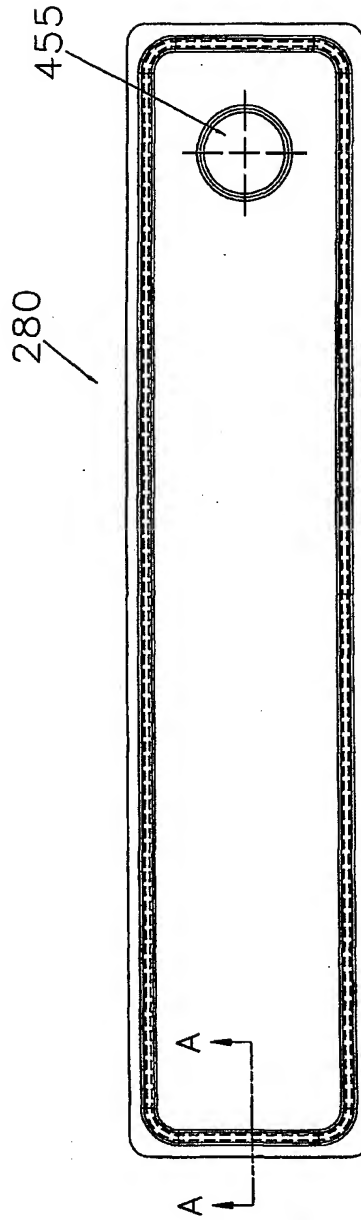


Fig. 17b

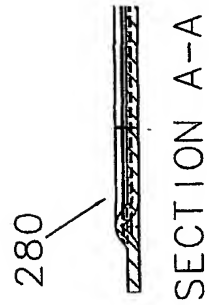


Fig. 17c

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Fig. 18a

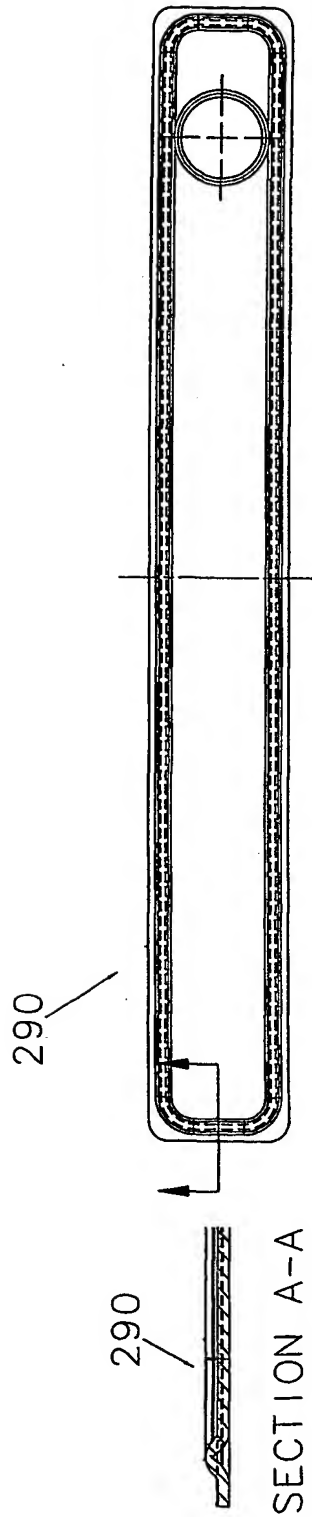


Fig. 18b

Fig. 18c

INTERNATIONAL SEARCH REPORT

In tional Application No

PCT/GB 01/02730

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 F28D9/00 F01N3/04 F28F3/04 F01N3/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F28D F01N F28F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 992 756 A (MODINE MFG CO) 12 April 2000 (2000-04-12)	1-3,5,8, 9,11,14, 15,21, 24-26
Y	column 4, line 35 -column 5, line 65; figures 5,6	4,6,7
Y	—	10,16-20
Y	US 6 047 769 A (SHIMOYA MASAHIRO ET AL) 11 April 2000 (2000-04-11) column 6, line 45 -column 7, line 4; figures 1-5	4,6,7
Y	FR 2 010 517 A (DELANEY GALLAY LTD) 20 February 1970 (1970-02-20) page 5, line 5 - line 33; figure 5	10,16-20
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Information on patent family members

International Application No

PCT/GB 01/02730

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